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EXPLORATIONS AND SURVEYS FOR A RAILROAD ROUTE FROM THE MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

WAR DEPARTMENT.

CONCLUSION

OF THE

OFFICIAL REVIEW OF THE REPORTS

UPON THE

EXPLORATIONS AND SURVEYS FOR RAILROAD ROUTES

FROM THE

MISSISSIPPI RIVER TO THE PACIFIC OCEAN.

WASHINGTON, D. C
1855-7.

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TABLE EXHIBITING THE COMPARATIVE LENGTHS, COST, ETC., OF THE DIFFERENT ROUTES, WITH EXPLANATORY REMARKS.

BY CAPTAIN A. A HUMPHREYS,
CORPS OF TOPOGRAPHICAL ENGINEERS

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PREFATORY NOTE.

Subjoined are extracts from the Annual Reports of the Secretary of War, transmitted to Congress in December, 1855 and 1856, and also the accompanying yearly reports of Captain A. A. Humphreys, Topographical Engineers, in charge of the office of Pacific Railroad Explorations and Surveys. These extracts and reports furnish, up to their respective dates, information in regard to the condition and progress of the several War Department explorations, and present the leading facts and results determined by each. They form, therefore, a proper conclusion to the series of special reports upon the different lines of survey.

An annexed table, similar to that contained in the Report of the Secretary of War, in Vol. I, exhibits the comparative lengths, cost, &c., of the various railroad routes, according to the latest corrections and revisions. Explanations are given of some of the more important modifications of the previously reported results.

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No. 1.

EXTRACT

FROM THE

ANNUAL REPORT OF THE SECRETARY OF WAR.

DECEMBER, 1855.

THE reports of the officers employed under the appropriations made for explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean, were submitted to Congress on the 27th of February last, with a report from this department, giving a general sketch of the country over which they extended, a recapitulation of their results, and a comparison of their distinguishing characteristics; from which it was concluded that of the routes examined, the most practicable and economical was that of the thirty-second parallel. A report is herewith submitted from the officer in this department charged with the revision of the work of the several parties, and I refer to it for additional information derived from materials collected, on a further examination of them by himself, and the several officers who made the particular surveys, as well as for the results of explorations carried on during the past year.

When the report was made, in February last, many of the maps, drawings, and scientific papers, intended to form part of the report, and which could only be prepared after an elaborate examination of the materials collected, had not been completed for want of time, and it became necessary to substitute hastily prepared drawings and preliminary reports. This was particularly the case with regard to the work on the route of the thirty-fifth parallel. A minute examination of the material collected in that survey has resulted in showing the route more practicable than it was at first represented to be, and in reducing to nearly one-half the original estimates of the officer in charge of the survey, which, indeed, seemed, when they were submitted, to be extravagant, and were noted in the report from this department as probably excessive.

Another feature of interest developed in the course of the further examination of the work on the route of the thirty-second parallel is, that the Colorado desert, which is traversed by the route for a distance of 133 miles, and which, in the report referred to, was noted as consisting of a soil that needed only water to render it highly productive, is, in fact, the delta of the Colorado river, and, according to barometric levels, is so much lower than that stream as to be easily irrigated from it. Thus, there is every reason to believe 4,500 square miles of soil of great fertility, of which nearly one-half is in our territory, may be brought into cultivation in one unbroken tract along the route.

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Under the appropriation made at the last session for the continuation of these surveys and other purposes, three parties have been in the field during the past season.

One of these was directed to make examinations connected with the routes of the 32d and 35th parallels. This survey has greatly improved the aspect of the former route by changing the line for nearly half the distance between the Rio Grande and the Pimas villages on the Gila river from barren ground to cultivable valleys, and entirely avoiding a *jornada* of eighty miles, which occurs in that section; also by the discovery of an eminently practicable route through cultivable country from the plains of Los Angeles, along the coast and through the Salinas valley, to San Francisco. The connexion originally proposed between these points was by way of the valley of San Joaquin and the Great Basin.

The attention of this party was also directed to an examination into the practicability of procuring water along certain parts of the route where it is now deficient. The report shows that it may be obtained by common wells at distances of about twenty miles.

From the result of this exploration, moreover, it appears practicable to obtain, at a small expense, a good wagon road, supplied with water by common wells, from the Rio Grande down the San Pedro and Gila and across the Colorado desert. Such a road would be of great advantage in military operations, would facilitate the transportation of the mail across that country, and relieve emigrants pursuing that route from much of the difficulty and suffering which they now encounter.

A second party was charged with the duty of testing the practicability of procuring water by artesian wells on the Llano Estacado, an arid plain, which has been heretofore described as a desert. The experiment has so far demonstrated its practicability as to leave little doubt of its final success; it will be continued, however, until the problem shall have been fully solved.

The examinations into the feasibility of causing subterranean streams to flow upon the surface from artesian wells, though undertaken in connexion with the practicability of a railroad, if they should prove entirely successful, will have a value beyond their connexion with that object in the reclamation of a region which is now a waste, and its adaptation to the pastoral, and, perhaps, the agricultural uses of man.

The third party was directed to conduct an exploration from the Sacramento to the Columbia river, with a view to ascertain the practicability of a route to connect the valleys of those rivers. The officer in charge has reported the successful completion of the duty, but has not given details. The same officer has been directed to make a reconnaissance of the Sierra Nevada in the vicinity of the head branches of Carson river.

The prosecution of instrumental surveys, accompanied by an investigation into many branches of physical science simultaneously over lines of such length, and embracing such an extent of latitude, is a work of greater magnitude than any of the kind hitherto undertaken by any nation; and its results have not only proved commensurate with the amount of work done, but possess a value peculiar to the scale on which it has been conducted, as affording a basis for the determination of some questions of science which no number of smaller and detached explorations could have furnished. Should means be granted pursuant to the estimate in the report referred to, for continuing these explorations, I have every confidence that the expenditure will be well repaid by these contributions to our knowledge of the interior of the country.

The facts developed by these surveys, added to other information which we possess, suggest some considerations of great interest with regard to our territory on the Pacific. They exhibit

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it as a narrow slope of an average width of less than one hundred and fifty miles of cultivable land, skirting the ocean for a distance of one thousand miles; rich in those mineral productions which are tempting even beyond their value, and which would be most readily turned to the use of an invader; drained by two rivers of wide-spread branches, and with seaports lying so directly upon the ocean that a hostile fleet could commence an attack upon any one of them within a few hours after being descried from land; or, if fortified against attack, so few in number that comparatively few ships would suffice to blockade them.

This territory is not more remote from the principal European States than from those parts of our own country whence it would derive its military supplies, and some of those States have colonies and possessions on the Pacific which would greatly facilitate their operations against it. With these advantages, and those which the attacking force always has of choice of time and place, an enemy possessing a considerable military marine could, with comparatively little cost to himself, subject us to enormous expenses, in giving to our Pacific frontier that protection which it is the duty of the general government to afford.

In the first years of a war with any great maritime power, the communication by sea could not be relied upon for the transportation of supplies from the Atlantic to the Pacific States. Our naval peace establishment would not furnish adequate convoys for the number of storeships which it would be necessary to employ, and storeships alone laden with supplies could not undertake a voyage of twenty thousand miles, passing numerous neutral ports, where an enemy's armed vessels, even of the smallest size, might lie in wait to intercept them.

The only line of communication, then, would be overland; and by this it would be impracticable, with any means heretofore used, to furnish the amount of supplies required for the defence of the Pacific frontier. At the present prices over the best part of this route the expense of land transportation alone for the annual supplies of provisions, clothing, camp equipage, and ammunition for such an army as it would be necessary to maintain there, would exceed $20,000,000; and to maintain troops and carry on defensive operations under those circumstances, the expense per man would be six times greater than it is now; the land transportation of each field twelve-pounder, with a due supply of ammunition for one year, would cost $2,500; of each 24-pounder and ammunition, $9,000; and of a seacoast gun and ammunition, $12,000. The transportation of ammunition for a year for 1,000 seacoast guns would cost $10,000,000. But the expense of transportation would be vastly increased by a war; and at the rates that were paid on the northern frontier during the last war with Great Britain, the above estimates would be trebled. The time required for the overland journey would be from four to six months. In point of fact, however, supplies for such an army could not be transported across the continent. On the arid and barren belts to be crossed, the limited quantities of water and grass would soon be exhausted by the numerous draught animals required for heavy trains, and over such distances forage could not be carried for their subsistence.

On the other hand, the enemy would send out his supplies at from one-seventh to one-twentieth the above rates, and in less time—perhaps in one-fourth the time—if he should obtain command of the isthmus routes.

Any reliance, therefore, upon furnishing that part of our frontier with means of defence from the Atlantic and interior States, after the commencement of hostilities, would be vain, and the next resource would be to accumulate there such amount of stores and supplies as would suffice during the continuance of the contest, or until we could obtain command of the

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sea. Assigning but a moderate limit to this period, the expense would yet be enormous. The fortifications, depots, and storehouses, would necessarily be on the largest scale, and the cost of placing supplies there for five years would amount to nearly one hundred millions of dollars.

In many respects, the cost during peace would be equivalent to that during war. The perishable character of many articles would render it perhaps impracticable to put provisions in depot for such a length of time; and in any case, there would be deterioration amounting to some millions of dollars per year.

These considerations, and others of a strictly military character, cause the Department to examine with interest all projects promising the accomplishment of a railroad communication between the navigable waters of the Mississippi and those of the Pacific ocean. As military operations depend in a greater degree upon rapidity and certainty of movement than upon any other circumstance, the introduction of railway transportation has greatly improved the means of defending our Atlantic and inland frontiers; and to give us a sense of security from attack upon the most exposed portion of our territory, it is requisite that the facility of railroad transportation should be extended to the Pacific coast. Were such a road completed, our Pacific coast, instead of being further removed in time, and less accessible to us than to an enemy, would be brought within a few days of easy communication, and the cost of supplying an army there, instead of being many times greater to us than to him, would be about equal. We would be relieved of the necessity of accumulating large supplies on that coast, to waste, perhaps, through long years of peace; and we could feel entire confidence that, let war come when and with whom it may, before a hostile expedition could reach that exposed frontier, an ample force could be placed there to repel any attempt at invasion.

From the results of the surveys authorized by Congress, we derive at least the assurance that the work is practicable; and may dismiss the apprehensions which, previously, we could not but entertain as to the possibility of defending our Pacific territory through a long war with a powerful maritime enemy.

The judgment which may be formed as to the prospect of its completion must control our future plans for the military defence of that frontier; and any plan for the purpose which should leave that consideration out of view, would be as imperfect as if it should disregard all those other resources with which commerce and art aid the operations of armies.

Whether we shall depend on private capital and enterprise alone for the early establishment of railroad communication, or shall promote its construction by such aid as the general government may constitutionally give; whether we shall rely on the continuance of peace until the increase of the population and resources of the Pacific States shall render them independent of aid from those of the Atlantic slope and Mississippi valley, or whether we shall adopt the extensive system of defence above referred to, are questions of public policy which belong to Congress to decide.

Beyond the direct employment of such a road for military purposes, it has other relations to all the great interests of our confederacy, political, commercial, and social, the prosperity of which essentially contributes to the common defence. Of these it is not my purpose to treat, further than to point to the additional resources which it would develop, and the increase of population which must attend upon giving such facility of communication to a country so tempting to enterprise, much of which having most valuable products, is beyond reach of market.

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No. 2.

REPORT

UPON THE

PROGRESS OF THE PACIFIC RAILROAD EXPLORATIONS AND SURVEYS.

NOVEMBER, 1855.

BY CAPTAIN A. A. HUMPHREYS, CORPS OF TOPOGRAPHICAL ENGINEERS.

WAR DEPARTMENT,
Office Pacific Railroad Explorations and Surveys,
Washington, November 29, 1855.

SIR: Since my report to you of February 5, 1855, the general map of the territories of the United States lying between the Mississippi river and the Pacific ocean has been completed as far as the materials collected admit, and is in the hands of the engraver. The labors of the parties organized for continuing explorations will afford data for still further additions.

Many of the maps, drawings, and scientific papers intended to form part of the reports submitted to you by the first exploring parties, soon after their return from the field, could only be prepared after an elaborate use of the materials collected. In some instances hastily prepared drawings and preliminary reports were temporarily substituted for the more elaborate results, which are now, for the most part, complete.

The results of the investigations in the various branches of physical science in connexion with the expeditions are of great practical value, and full of scientific interest. The geological and meteorological reports are eminently so in many points of view. By the former it will be perceived that the sources and quality of building materials at various remote and important localities have been determined, and rich deposits of gypsum and limestone have been marked out. On the routes of the 35th and the 32d parallels, the structure of desert areas has been minutely studied with special reference to the practicability of obtaining water by wells or by boring, and generally with the most satisfactory results. From the report of Mr. W. P. Blake, the geologist of the expedition in charge of Lieutenant R. S. Williamson, it appears that the structure of the Colorado desert, between Fort Yuma and the Coast mountains is very favorable to the success of artesian borings, and it is considered probable that an abundant supply of water would be obtained by boring to a moderate depth. Such a result would be of extreme importance, not only by facilitating communication between Fort Yuma and the coast for government trains, but as a relief to the emigrant parties which are constantly crossing to California through New Mexico and Sonora. The general nature and composition of the soils and sub-soils over the region explored has been determined, and analyses of the most

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desirable have been made. An analysis of the soil of the alluvial portion of the Colorado desert, which covers an area of 4,500 square miles, and is four times greater in extent than the land under cultivation on the Mississippi river, between the mouth of Red river and the Balize, shows that it has all the elements of great fertility, and, but for the adverse climatic conditions, would rival in its productions the best lands of the delta of the Mississippi. According to the barometrical levellings of Lieutenant Williamson, the alluvial portion of this plain is lower than the surface of the Colorado river; and should this be confirmed by more accurate modes of levelling, as there is every reason to believe it would be, an extensive system of irrigation would entirely change the character of its surface by the introduction of water, the only element required for great productiveness. About one half of the Colorado desert is within our territory.

Valuable ores of several metals have been brought in and examined, and their localities visited and described. A specimen from the collection of Captain Pope proves to be a mass of carbonate of lead, nearly pure, and containing seventy-two per cent. of metal. Another specimen of earth, from the bed of Delaware creek, contains over eighteen per cent. of free sulphur. In California two veins of copper ore, one of iron, and one of antimony, of great extent and richness, have been found and reported upon; worth alone the whole cost of Lieutenant Williamson's expedition. The character and extent of large deposits of bitumen asphalt near Los Angeles has also been made known. The examination of a collection of salty and alkaline incrustations from the soil and dry lakes of California, shows that they consist principally of salt, sulphate of magnesia, and carbonate of soda. Nitre was not found in any quantity.

Along the 35th parallel the carboniferous limestone has been found as far west as the San Francisco mountain, in longitude 112°. The discovery of these rocks so far west renders it possible that deposits of true coal will be found in that region, although, the observations having been very limited, none has yet been seen. The probable existence of coal in other new and important localities has been indicated, which more thorough examinations may develop. Much additional geological exploration is required to throw light on this important subject.

The character of the sand-hills of the Colorado desert has been carefully considered by Mr. Blake, who has shown that they are confined in position to a bank or terrace, and, contrary to the opinion previously entertained, do not constitute a formidable obstacle to the construction and working of a railroad.

Among the results of special scientific interest is the determination of the geological age of mountain chains. It has been ascertained that the coast mountains, in the vicinity of San Francisco, and further south, have upraised within or since the Eocene division of the Tertiary period. The strata about San Francisco, Benicia, Monterey, and other localities, have been shown to be of Tertiary age, and the foldings and contortions to which they have been subjected reveal the violent disturbances and mighty changes of that part of the continent within recent geological times. Tertiary marine shells and sharks' teeth have been brought from the tops of hills, at the base of the Sierra Nevada, over 1,500 feet above the ocean.

Of similar interest are the examination and description of volcanoes, the exhibition of the nature of the rocks and soils along the several routes, by large collections of rocks, minerals, and fossils, and the comparison of the ages of mountains, and the strata on their flanks. These additions to our knowledge of the geological structure of the country have been of great assistance in determining its general features and topography.

The results of the investigations into the zoology and botany of the country west of the Mississippi have proved interesting and important. The existence and geographical distribution

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of many species, useful in an economical point of view, or interesting to science, have been determined.

The precise range of the buffalo, the antelope, the prairie dog, the various species of deer, and of other animals, with that of numerous valuable trees and herbaceous plants, has been satisfactorily ascertained. Several forms of animal and vegetable life, noticed by earlier travellers, especially by Lewis and Clark, but unknown since their time, have been re-discovered.

The labors of the naturalists and the collectors attached to the several parties have resulted in a collection illustrating the natural resources of our country west of the Mississippi, more complete than will be found in all the museums of the United States and Europe combined.

Lieutenant Williamson's report shows a remarkable coincidence of the elevations deduced from barometrical observations with those obtained at the same time by the spirit level. The profiles of the Tejon pass and the Cañada de las Uvas, delineated from the spirit level altitudes, differ so slightly from the barometrical profiles, that the barometer may be regarded as sufficiently accurate for the purpose of railroad reconnaissance in that climate.

The report of Captain Whipple, topographical engineers, upon the manner in which the elevations for the elaborated profile of his route have been deduced, indicates means by which great accuracy can be obtained in barometrical levelling over extensive regions, without the delay consequent upon the mode of eliminating those errors arising from irregular changes of atmospheric pressure, by simultaneous observations at near points. Between the Mississippi and the Pacific, these errors are in some instances equal to 1,000 feet. The investigation made by Captain Whipple leads to the following conclusions, regarding these irregular movements of the barometer:

1st. They are of great magnitude, and if not taken into account may produce an error in the deduced altitude of many hundreds of feet.

2d. They are but slightly affected by local storms.

3d. They *may* occur almost simultaneously over the whole interior portion of the continent.

4th. They are actually identical within certain areas of great extent.

These conclusions will be regarded with great interest by scientific explorers and those engaged in studying and observing meteorological phenomena.

It has been suggested, in connexion with this, to make series of barometrical observations at military posts on lines crossing our territories from east to west, in order to determine the areas over which these irregular (abnormal) movements occur simultaneously. These having been ascertained, it will be merely necessary, in future explorations, to have corresponding observations made at one point in each of the barometrical areas, or regions, traversed by an expedition. The plan of observations proposed could be carried into effect at the cost of a few thousand dollars; and, incidentally, would make important additions to meteorological knowledge.

As a kindred subject, I beg leave to ask your attention to a proposed arrangement for improving the means of computing the observations for longitude of exploring parties. The best mode of determining longitudes by these parties, is that of observations upon moon culminating stars. One night's observations by a good observer will give a resulting longitude—the error of which will not exceed two miles, provided there are corresponding observations at some well determined point; but without these corresponding observations, errors, three or four times as great, may be introduced by the use of tables of the computed positions of the moon. Thus it appears that the field observations are more accurate than the means of computing used

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in the office. This source of error could be obviated by a preconcerted arrangement with an observatory for observations, at certain times during the continuance of exploring parties in the field.

Upon reviewing his barometrical work for the correction of errors due to abnormal changes, Captain Whipple has included a mass of altitude observations, not reduced before for want of time, which gives a remarkably detailed and accurate profile of the ground; and in connexion with the equally minute topographical notes, now for the first time used, has greatly improved the character of his route as a railroad line.

Among the most important changes that the revision has introduced, Capt. Whipple reports the reduction of the length of the route, which from Fort Smith to San Pedro is now 1,760 miles, and from Fort Smith to San Francisco, direct from the Mojave river by the Tay-ee-chay-pah pass, avoiding the tunnel of the Cajon pass, it is 2,025 miles. In the preliminary report the distances were measured upon the wagon trail; those now given are along the plotted railroad line. Many of the difficulties of construction previously reported may, in the judgment of Capt. Whipple, be obviated; and, in his opinion, there is strong probability of improving the route still further, by shortening distance and avoiding costly construction. A scrutiny of the barometrical observations through Campbell's pass of the Sierra Madre, about twenty miles north of the Camino del Obispo, shows that that mountain chain may be crossed without a tunnel or excavation at the summit, with a maximum grade of 40 feet to the mile, at an elevation of 6,952 feet above the sea. By the Camino del Obispo, the old route, elevation 8,250 feet, a tunnel three-quarters of a mile long, at an elevation of 8,000 feet, was required.

The elevations of several of the passes have been materially reduced; and Captain Whipple reports that the data are now provided for an actual computation of the excavation, embankment, and cost of construction of the proposed route.

As this computation necessarily involves much tedious labor, it has not yet been made, and for the present Captain Whipple submits an estimate made in a manner similar to those of the other routes, in order to exhibit more correctly the comparative practicability of this, than was done in the preliminary report. He has based it upon the facts developed by a careful study of the observations made and the material collected in the field, and it is believed by him that the amount will be much diminished when the results of the computation are arrived at. The cost of construction, as given in the preliminary report, was greatly exaggerated, the estimates having been formed without reference to the field notes. In the examination which, by your direction, I made of that report, the estimates were thought by me to be largely in excess. They were—

From Fort Smith to San Pedro, distance 1,892 miles	$169,210,265 00
From Fort Smith to San Francisco, the road leaving the Mojave river 34 miles from the east entrance of Cajon pass, and crossing the Tay-ee-chay-pah pass, (the estimate from the Mojave river to San Francisco, a distance of 406 miles, having been made by me) distance 2,174 miles	175,877,265 00

These, according to Captain Whipple, are now—

From Fort Smith to San Pedro, distance 1,760 miles	86,130,000 00
From Fort Smith to San Francisco, crossing direct from the Mojave river to the Tay-ee-chay-pah pass, distance 2,025 miles	94,720,000 00

Under the appropriation for continuing explorations and surveys to ascertain the most practicable and economical route for a railroad from the Mississippi river to the Pacific ocean, three parties were organized by your directions.

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The first, under the command of Lieutenant John G. Parke, topographical engineers, was instructed by the letter of the Department of October 2, 1854, to determine the practicability of constructing a railroad from the waters of the bay of San Francisco to the plain of Los Angeles, by the Salinas river valley, and through the spurs of the Coast Range, which extend to the sea coast near Point Concepcion, or, if that was found to be impracticable, by the coast route; to make certain explorations in the Great Basin, in connexion with the route of the 35th parallel, and between the Pimas villages on the Gila and the Rio Grande; the attention of the party being particularly directed to such examinations in the latter region as would show the degree of practicability of constructing artesian and common wells. These duties have been thoroughly and satisfactorily executed, and the party has just returned to Washington from the field. A rough reduction of portions of the field-work, at the most difficult points, shows that a railroad route from the headwaters of the Salinas, through the spurs of the Coast Range, direct to the plains of Los Angeles, is not practicable; whilst that along the coast route is eminently so. With equal length, it has the advantage over the route by New (Williamson's) and Tay-ee-chay-pah passes, of a less sum of ascents and descents, less elevation, (the greatest attained being only 1,350 feet above the sea,) less cost of construction, and of passing continuously through a settled and cultivated country. The grades are favorable, the greatest required being, with a cut of 60 feet at the summit, 125 feet per mile for the space of 15 miles, (ascending and descending;) and this, it is believed, can be reduced to 100 feet per mile, by a tunnel 1,000 feet long.

The labors of the party will develop the topography of a district that was before unknown, or the nature of which was greatly misconceived; and will show a practicable railroad route, with easy grades, connecting the valley of Salinas river with the head of Tulare valley, by the Estrella, a tributary of the Salinas, and the Estero, a plain lying within the Coast Range, and connected with the Tulare valley, near the Cañada de las Uvas. The exploration in the Great Basin was successfully executed, demonstrating that the Mojave river is a stream of the Great Basin, and does not flow into the Colorado at any time; an elevated ridge separating the basins of the two rivers.

The topographical examinations between the Pimas villages on the Gila and Doña Ana, or El Paso, on the Rio Grande, have resulted in many important improvements upon the line of survey of last year. They have established the practicability of constructing a railroad between those points, by the Gila river, to the mouth of the San Pedro, and up that stream to the vicinity of the line of 1854; a route possessing great advantages over all others in this region, since, from the Pimas villages to the point of departure from the San Pedro, a distance of 166 miles, it passes along the cultivable valleys of those streams, instead of over bare jornadas. The ridge of mountains east of the San Pedro is crossed by a more direct route than that of the old line, and the Puerto del Dado of the Chiricahui mountains is avoided, that range being turned on the north by a gap or break lying between it and Mount Graham. The length and the cost of construction of this route will be about the same as of that examined by Lieutenant Parke, in 1854; the summits to be overcome will be fewer in number, the elevations less, the grades more gentle, and the supply of water greater; these, with the great advantage first mentioned, constitute this the best route yet made known in that region. The results of the examinations with reference to the supplies of water make it probable, from the form and geological structure of the basins and plains, that ordinary wells, at distances not exceeding twenty miles, would furnish abundant supplies, distances not too great for the economical working of passenger

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trains. They also indicate the feasibility of artesian wells in some localities, which might be resorted to if needed.

Upon the arrival of Lieutenant Parke at Fort Fillmore, after the completion of this duty, a report was made by him to this office of the principal results bearing upon the question of supply of water, of the points where it was desirable to have borings made, indicated in the order most suitable for trial, together with all the information necessary for the party directed to make the borings. A copy of this was furnished by Lieutenant Parke to Captain Pope, then engaged in the construction of an artesian well near the Pecos, who had been previously instructed to make the requisite borings west of the Rio Grande, upon the successful completion of the first duty assigned him.

By the construction, at no great cost, of a series of eight common wells between the Rio Grande and the San Pedro, and a series of four or six across the plain known as the Colorado Desert, and the expenditure of a few thousand dollars in making the route along the San Pedro and the Gila, to the Pimas villages, practicable for wagons, an excellent emigrant and mail route for coaches will be had, and great suffering be saved to those crossing the continent in this latitude. This route will be much shortened, and its value still further increased, by constructing a series of artesian wells, not exceeding five in number, across the Llano Estacado. The party of Lieutenant Parke is now engaged in the reduction of the field-work and preparation of the reports, maps, &c.

The duty assigned to the second party organized under the direction of Brevet Captain John Pope, topographical engineers, by the instructions of the Department of January 5, 1855, was that of testing the practicability of procuring water by artesian wells on the arid plains of the interior.

The point selected for the first trial was upon the Llano Estacado, near latitude 32°, about fourteen miles east of the Pecos, at the mouth of Delaware creek, where water for the use of the party could be conveniently obtained from the river. The party arrived at this point in the latter part of May, and commenced the operation of boring. At the depth of three hundred and sixty feet water was reached, which rose immediately seventy feet in the well, and remained at that height—the level of Delaware spring. It was found that the various strata of sandstone passed through in boring did not possess the degree of hardness reported by Mr. Marcou, the geologist, who examined the geological collection made by Captain Pope when crossing the Llano the preceding year; and in consequence, after some delays from the caving in of the sides of the well, it was found necessary to line it with tubing throughout. From the reported character of the formation, five hundred feet of tubing was considered sufficient for all the experiments the party was directed to make, less than half of which would be required for the well of the Llano Estacado; but the unexpected softness of the strata made it necessary to use all the tubing in the first five hundred feet. About the middle of September, at the depth of six hundred and forty feet, a second supply of water, pressed up through sandstone, was attained, which rose three hundred and ninety feet in a few minutes, and was still rapidly rising, when the caving in of the marly clay below the tubing filled in the well to the height of seventy feet, and effectually cut off the communication of the subterranean reservoir or stream with the surface. An attempt was made to remove this accumulation with the mud pumps, but, after a continuous labor of twelve days and nights without making any impression upon it, the attempt was discontinued, as without additional pipe the well could not be finished; and, in the opinion of Captain Pope, the practicability of constructing artesian wells on the Llano Estacado had been fully established. The party then proceeded to the execution of the second duty assigned to it.

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This result having been reported to the Department, by your directions, measures were taken to supply additional tubing to Captain Pope, who has been instructed to resume the work on the Llano.

In the opinion of the officer charged with the operation they had, at the depth of six hundred and forty feet, closely approached coal measures, and he was convinced that a clear stream or reservoir would have been found twenty feet lower. From his report and accompanying diagram it appears that, at five hundred and seventy feet, a stratum of dark blue shale of the coal measures was pierced. It is highly probable that the water, which appeared at the depth of six hundred and forty feet, pressed up through the lower portion of the stratum of sandstone which they had been boring through for the last sixty feet, would have risen to the surface in large quantities. As the first supply of water rose to within two hundred and ninety feet of the surface, it might reasonably be concluded that, if another supply were attained three hundred feet below the source of the first supply, it would rise to the surface; the bottom of the boring was within twenty feet of this point when the second supply was pressed up through sandstone. The level attained by the first supply of water was that of Delaware spring. At Independence spring, which is west of Delaware spring, and six hundred feet above it, the upper carboniferous formation of the Guadalupe mountains begins. If the strata of sandstones, indurated clays and marls, found between these two springs, should extend under the Llano Estacado, parallel to each other and of equal thickness, it was probable that, at a depth of six hundred feet below the point at which the first supply of water was reached, (coming from the same level as Delaware spring,) the second supply would be had coming from the upper carboniferous strata and the level of Independence spring; but as the blue shale of the coal measures was reached at one-half this depth, it would appear that the strata are about three hundred feet apart at the point where the boring was made, instead of six hundred feet, as they are between Delaware and Independence springs. These conclusions are dependent upon the fact reported by Captain Pope, that the dip of the strata is very slight, being nearly coincident with the slope of the surface of the ground. Both supplies of water in the well were clear, pure, and palatable, free from any impurities appreciable by the tests at the command of the geologist, Dr. Shumard. An important result of this boring is the probable existence of coal in the carboniferous formation which appears upon the surface at the foot of the Guadalupe mountains.

The instructions of the Department required Captain Pope, after the successful completion of the well on the Llano Estacado, or the demonstration of its impracticability, to make borings at certain points west of the Rio Grande on the route to be examined by Lieutenant Parke's party, in order to determine the practicability of artesian wells there, and the depths at which water can be had (by ordinary wells) at the dryest season, and the thickness of the water-bearing strata. By the time this duty is completed, it is probable that he will have received the additional tubing necessary to the successful completion of the artesian well on the Llano Estacado, and will then be enabled to resume that work.

The importance of obtaining large supplies of water on the interior plains and basins, by the construction of artesian wells at moderate cost, is too apparent to need exposition.

The greater part of the rain and other precipitation in those arid regions falls upon the mountains, and percolating through the loose debris on their flanks, descends below the surface of the plains, appearing again, sometimes at great distances, in springs and streams—the sources of rivers.

On the plains and table lands of Asia, which so closely resemble those of North America that

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a description of one may be taken for the other, water for irrigation, where no streams are found, is obtained by a series of wells connected by subterranean conduits. This laborious process is extensively used, and converts waste barren land into productive fields.

If to a demonstration of the practicability of constructing artesian wells at moderate cost on the interior plains and table-lands be joined the discovery of coal beds, fertility, industry, and wealth may be made to take the place of sterility and solitude over extensive areas of those arid, naked, and treeless districts.

A third party, under the command of Lieutenant R. S. Williamson, topographical engineers, was organized, under instructions from the department of May 1, 1855, to explore, first, the region between the Sacramento and Columbia rivers, to ascertain the practicability of connecting them by railroad; second, to make examinations and surveys near the sources of Carson river, to ascertain the practicability of crossing the Sierra Nevada in that vicinity by railroad, provided the information obtained from the troops and others who had recently crossed the mountains by that route should indicate the probable existence there of a railroad route. By a report of this officer of the 19th of October, the first duty has been successfully executed.

In addition to the immediate practical value of these explorations in ascertaining the best routes suitable for rail and common roads; their importance from military considerations; their usefulness in making known shorter and better routes of travel to emigrants by which much suffering and loss is avoided; their value in indicating additional sources of national wealth and strength; in substituting exact knowledge for vague surmise and the entirely unknown; the large amount of valuable information collected by them respecting the physical features and condition of our country in topography, geography, and geology, meteorology, botany and zoology, render it highly desirable to continue them.

Many portions of the interior are entirely unknown; and for continuing their exploration during the following year an appropriation of one hundred and fifty thousand dollars could be well expended.

Very respectfully, your obedient servant.

A. A. HUMPHREYS,
Captain Top. Engineers in charge

Hon. JEFFERSON DAVIS,
Secretary of War.

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No. 3.

EXTRACT FROM THE ANNUAL REPORT OF THE SECRETARY OF WAR, DECEMBER, 1856.

A report is herewith submitted from the office of this Department connected with the explorations made to ascertain the most practicable route for a railroad to the Pacific, to which I refer for a detailed account of the duties performed in that relation during the past year.

My last annual report contained a brief reference to the principal results of the explorations and surveys made during that year in connexion with the routes near the 35th and 32d parallels, and between the Gila and Rio Grande. The report of the officer charged with these duties shows the proposed railroad line between the bay of San Francisco and the plain of Los Angeles to be an eminently practicable route. It occupies the valley of the San José and Salinas rivers; crosses the Santa Lucia mountains near San Luis Obispo; traverses the rolling country adjacent to the coast as far as Tres Alamos river, and thence, to the mouth of the Gaviote creek, passes either along the valley of Santa Inez river and the Gaviote pass, or follows the coast, turning Point Concepcion; from the mouth of Gaviote creek it follows the shore line to San Buenaventura, and crosses the Santa Clara plain, the Semi pass, and San Fernando plain to Los Angeles.

The distance from San José, near the bay of San Francisco, to Los Angeles, by the shortest line, is 396 miles. Two tunnels are proposed, each three-fourths of a mile in length, one on the San Luis pass, through the Santa Lucia mountains, and the other in the Semi pass. The estimated cost of this route, including equipment, is $20,823,750, or about $52,600 per mile.

A favorable pass, leading from the valley of the Salinas river to the Tulare valley, was discovered by this party, forming a good connexion with the bay of San Francisco for the route of the 35th parallel.

The results of the survey, it was formerly stated, have greatly improved the aspect of the first route surveyed between the Pimas villages, on the Gila, and the Rio Grande, by changing the line for nearly half the distance from barren ground to cultivable valleys, and entirely avoiding a *jornada* of eighty miles which occurs in that section. The route now follows the valleys of the Gila and the San Pedro rivers to the mouth of the Aravaypa, a tributary of the San Pedro, discovered by this party; continues up that stream to its source; crosses between Mount Graham and Chiricahui mountains by a very favorable pass; proceeds in a direct course through the Peloncillo mountains, and joins the former line in the vicinity of Colonel Cooke's emigrant road. From this point to the Rio Grande the route lies in the lowest line of the depression which characterizes the plateau of the Sierra Madre in this latitude, the mean elevation of which is about 4,400 feet above the level of the sea, the summit being 4,600 feet above that level.

The maximum grade upon this route is 64.4 feet per mile. The route for two-thirds of the

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distance is represented as being most favorable for a railroad; the remaining one-third being nearly equally divided between ground of a rolling and mountainous character.

The examinations of this party, in reference to the practicability of procuring water, show that it may be obtained at suitable distances by common wells and conduits, supplied from permanent streams. In some localities artesian wells might probably be resorted to successfully.

The estimated cost of the whole distance, 345 miles, is $15,300,000, or about $44,000 per mile. The estimate, based upon a thorough re-examination of the ground, and a close study of the subject by the officers in charge of the survey, coincides very nearly with that made by the officer who presented the general revisory report upon the first explorations.

It is deemed proper to call especial attention to this coincidence, so strongly exhibiting the general reliability of these estimates, because a minority report made at the last session of Congress, from a committee of the House of Representatives, characterized the estimates, based on the reconnaissances of the topographical engineers, as unreliable, and adduced to sustain that disparaging reflection, the fact that on one of the lines explored, the preliminary estimate of the officer in charge greatly exceeded that which he presented after a further study of his observations in the field; this, too, being in disregard of the fact that the first estimate was hastily made by the explorer to meet a pressing demand for his report, and was at the time stated by him to have been prepared in anticipation of the future examination of the data he had collected. In the remarks of the revising officer which accompanied the reports it was also pointed out that this estimate was probably largely in excess.

Although the two lines between the Gila and Rio Grande, of which the estimated cost is so nearly alike, are over different routes, the features of the ground, so far as they would affect the cost of construction of a railroad, are nearly identical; the advantages of the new line depending upon other considerations already enumerated.

Similar remarks may be applied to the estimated cost of the two routes between the plains of Los Angeles and San Francisco, though the coincidence there is not so close, the character of the ground being such as would cause a difference of expense in the road bed formation.

In addition to his own results, the officer in command of this party has presented those of an instrumental survey from San Diego bay, through Warner's pass, to the Colorado desert, made under the auspices of the San Diego and Gila Railroad Company.

The engineer of this company estimates the cost of a railroad on this route from San Diego to Fort Yuma, distance 189.1 miles, at $7,571,500; one half of this distance being estimated at $14,615 per mile, and the other half at $65,085 per mile. These estimates are much less than those contained in the reports of the officers of this Department for routes passing over similar ground. Either standard of cost per mile applied to the routes from Fort Yuma to San Diego and from Fort Yuma to San Pedro, through the San Gorgonio pass, gives about the same total amount of cost for each route. The line to San Diego forms the shortest route to the Pacific, the distances being, from Fulton to San Diego, 1,548 miles; from Fulton to San Pedro, 1,618 miles. If the final terminus of a Pacific railroad is to be San Francisco, the route through the San Gorgonio pass to San Pedro is preferable to that to San Diego, since the former port is about 100 miles nearer to San Francisco.

The party directed to explore the country between the Sacramento and Columbia rivers, with a view to ascertain the practicability of connecting these valleys by a railroad, examined two routes—one east, the other west of the Cascade range.

The former accomplishes the passage of the western chain of the Sierra Nevada by following

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Pit river. The route then traverses a sterile plateau, elevated from four to five thousand feet above the sea, to the head of the Des Chutes river. Serious obstacles to the construction of a railroad are encountered at the cañons of Pit river, and near upper Klamath lake. Wood and water are sufficiently abundant. The deep cañons in which the Des Chutes river and its tributaries flow render it impracticable for a railroad to follow its valley to the Columbia river. A practicable, although difficult, pass was examined through the Cascade range near Diamond Peak, by which the road can reach the Willamette valley; the route through which to the Columbia is very favorable to the construction of a railroad. The route west of the Cascade range is through the Willamette, Umpqua, Rogue River, and Shasta valleys. It proved to be more favorable than had been anticipated; and had not the smallness of the party and its inability to obtain an escort during the existence of Indian hostilities prevented lateral reconnaissances, it appears probable that a practicable line to Fort Reading would have been found, traversing for nearly the whole distance a fertile and inhabited region.

Between the Columbia river and Fort Lane in Rogue River valley, the Calapooya mountains, Umpqua mountains, and the Grave Creek hills are the chief obstacles to the construction of a railroad. An excellent pass through the first, and a difficult, but practicable, pass through the second, were surveyed. The Grave Creek hills, it is thought, can be turned.

Information respecting a pass from Rogue River valley to the plateau east of the Cascade mountains makes it probable that an easy connexion with the first route examined may be made, and this will be especially important should the obstacles encountered between Fort Lane and Fort Reading be shown by further examination to be insurmountable.

The pass examined through the Siskiyou mountains, which separate Rogue River and Shasta valleys, was very unfavorable to the construction of a railroad.

From Shasta valley to Fort Reading the route over the Scott and Trinity mountains is reported utterly impracticable. A feasible location between these places might be obtained by following the Sacramento valley.

The route east of the Cascade range may be considered practicable. The total distance by it from Benicia to Vancouver is about 800 miles, of which only 350 miles are in a fertile and settled region. The construction for about 250 miles would be very difficult and costly; for the remainder of the distance the work would be light.

The principal advantage of a route west of the Cascade Range would consist in its traversing a fertile and inhabited country. By the line surveyed the total distance from Benicia to Vancouver is 680 miles, of which 500 would be easy of construction, 100 difficult and costly, and 80 so difficult and expensive as to be considered impracticable.

Additional experiments have been made during the past year by the party previously engaged in testing the practicability of procuring water by means of artesian wells upon the Llano Estacado, and upon the table lands west of the Rio Grande. In the latter region the trial has not been prosecuted sufficiently far to admit of satisfactory conclusions. The work upon the Llano, which had been suspended until additional tubing could be procured, was resumed, and a well has been sunk to the depth of 861 feet. At the depths of 245 and 676 feet seams of pure and palatable water were laid open; the first rising in the well twenty-five feet, and the second to within 110 feet of the surface. As no water rose above this point it has not yet been practically demonstrated that, in this region, there are subterranean streams which can be made to flow upon the surface; but nothing has been developed to change the

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opinion, heretofore expressed, that the experiment will be attended with success, if prosecuted to the depth then contemplated by the Department.

More detailed information regarding the late operations will be found in the report from the office connected with these explorations.

The well has been left in such condition that the boring may be continued from the point where it ceased, should future appropriations admit the resumption of the work.

The important results that may attend the solution of this question, not only in connexion with the construction of a railroad, but also in the development of the resources which the country may contain, have been already noticed in previous reports from this Department.

The topographical surveys carried on in connexion with this work have improved the location of that portion of the railroad route near the thirty-second parallel east of the Rio Grande.

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No. 4.

REPORT

UPON THE

PROGRESS OF THE PACIFIC RAILROAD EXPLORATIONS AND SURVEYS.

NOVEMBER, 1856.

BY CAPTAIN A. A. HUMPHREYS, UNITED STATES TOPOGRAPHICAL ENGINEERS.

WAR DEPARTMENT,
Office Pacific Railroad Explorations and Surveys,
Washington, November 29, 1856.

SIR: At the date of my last report, November 29, 1855, the party of Lieutenant John G. Parke, topographical engineers, had just returned to Washington from the field. Since then it has been occupied in preparing the reports and maps of the survey, which are now nearly completed.

By instructions from the department, of October 2, 1854, Lieutenant Parke was directed to make explorations to determine the practicability of constructing a railroad from the waters of the bay of San Francisco to the plain of Los Angeles, by the Salinas river valley, and through the spurs of the Coast range, which extend to the seacoast, near Point Concepcion; or, if that was found to be impracticable, by the coast route; to make certain explorations in the Great Basin, in connexion with the route of the 35th parallel, and to explore the country between the Pimas villages on the Gila and the Rio Grande; the attention of the party being particularly directed to such examinations in the latter region as would show the degree of practicability of constructing artesian and common wells.

The survey was commenced at San José, California. The route lay through the Santa Clara, or San José valley, to the Pajaro river; down the valley of this stream to near its debouche into the bay of Monterey; around the foot hills of the Gavilan range of mountains to the Salinas plains and the valley of the Salinas river, and up the Salinas river to Santa Margarita, at the base of the San Luis pass.

Thus far, no material obstacles were presented to the construction of a railroad; the Santa Clara valley and Salinas plains affording a peculiarly favorable location for it. A bridge across the Pajaro and some light earth work at the terminal spurs of Mount Gavilan, and in the valley of the Salinas, between the mouth of the San Lorenzo and Santa Margarita, constitute the

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heaviest portion of the work for this distance of one hundred and seventy-seven miles. The maximum grade required will be seventy feet per mile, for two miles.

A month was devoted to a thorough examination of the headwaters of the Salinas river. Reconnoitring parties were sent forward to examine the main stream and its largest tributary, the Estrella and the Cuyama plain, or valley of the Rio de Santa Maria, beyond, while a detailed survey of the San Luis pass was being made. The explorations about the heads of the Salinas and the Cuyama plain prove that a line through this country would be impracticable. An extensive basin was discovered—the Llano Estero—a tributary to the Tulare valley, which affords a very favorable pass from that valley to the bays of Monterey and San Francisco; the elevation of the summit being about 1,800 feet above the sea. The approach from the Tulare valley is over a plain for about forty miles. The distance from this pass to Kern lake is sixty-five miles.

The elevation of the lake above the sea, according to Lieutenant Williamson, is three hundred and ninety-eight feet. It is believed that a grade of sixty feet per mile will accomplish the descent from the summit, westward, to the Estrella. The average grade of Estrella creek to its mouth at San Miguel is about twenty feet per mile.

The route was continued across the Santa Lucia mountains, through the San Luis pass, to the seashore. A detailed survey of this pass was made. It is a sharp divide, composed of slightly metamorphosed sandstone and serpentine rock. The elevation of the summit was found to be 1,556 feet above the sea. It is proposed to tunnel this pass for three-fourths of a mile, commencing at a point about 200 feet below the summit. The maximum ascending grade would be 80 feet per mile. The San Luis creek heads on the seaward side of this pass, and descends rapidly to the plain through a wide valley, flanked on either side by rib-like spurs from the mountain. The descent of the stream is too great to admit the location of the road through or near San Luis Obispo; but, four and a half miles below its source, there is a lateral ravine, from the summit of which the line may be carried along the slopes of the mountains to the small divide between Corral de Piédras creek and Arroyo Grande, a stream running to the Pacific, whose slope, from the point where it is reached, admits of railroad location as far as its mouth. From the summit of the San Luis pass to the ocean, a grade of 100 feet per mile would be required for fourteen miles. This section constitutes the boldest feature of the route between San Francisco and Los Angeles. Lieutenant Parke is of opinion that for temporary purposes this pass can be surmounted without a tunnel, by resorting to a system of short curves and heavy grades—the greatest 200 feet per mile—similar to that adopted in the location of the Virginia Central Railroad across the Blue Ridge at Rockfish Gap, where the maximum grade is 275 feet per mile. The examinations in the vicinity of San Luis Obispo having been completed, the region lying between the ocean, the plains of Los Angeles, the western edge of the Great Basin, and the heads of the Tulare and Salinas valleys was thoroughly explored. The line adopted as most favorable commences at the Arroyo Grande; traverses the Guadalupe Largo; ascends the Todos Santos summit; descends to the Rio de Tres Alamos; crosses the spur between Rio de Tres Alamos and the Santa Inez river; passes to the summit of the Gaviote pass at Santa Cruz—elevation, 700 feet—and, through the lower portion of the Gaviote pass and creek, to the coast. The maximum grade upon this line is 100 feet per mile, for $5\frac{1}{2}$ miles, through the Gaviote cañon. From the summit of the Gaviote pass (at Santa Cruz) to the ocean, the location will be bold; requiring heavy work in earth and rock (sandstone) to keep up the grade. A lofty structure will be required across the Gaviote creek, and a heavy cut through a salient

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point at its mouth. The route around Points Purissima, Arguello, and Concepcion is 14 miles longer. It lies wholly on the terraced shore, and at no point is over 100 feet above the sea.

From Gaviote creek to San Buenaventura (60 miles) the character of the location will be the same as that of the route around Point Concepcion, being near the shore and on the terraces.

The most favorable route from San Buenaventura, or the Santa Clara river, follows the Semi plain and pass to the San Fernando plain. The Semi pass divides the San Fernando plain from the Santa Clara plain. A tunnel is proposed here, which will not exceed three-fourths of a mile in length, and, upon closer survey, may be materially shortened. The rock is sandstone of easy cleavage. The summit of this pass is 1,577 feet above the sea; the summit of the grade, 976 feet above that level. The ascending and descending grades are light. The San Fernando and Los Angeles plains are separated by a narrow valley. The route from San José, on the waters of the bay of San Francisco, to near Los Angeles, is divided into nine parts. The length of each division, the maximum grade, and approximate cost are presented by Lieutenant Parke, as follows:

Division.	Length.	Maximum grades, &c.	Cost per mile.	Total cost.
	Miles.			
1	39.25	18 feet per mile.	$30,000 00	$1,177,500 00
2	20.75	11 feet per mile.	55,000 00	1,141,250 00
3	45.50	6½ feet per mile.	30,000 00	1,365,000 00
4	71.50	70 feet per mile.	50,000 00	3,575,000 00
5	24.50	100 feet per mile.	117,142 00	2,870,000 00
6	32.50	63.2 feet per mile.	30,000 00	975,000 00
7	33.50	100 feet per mile.	80,000 00	*2,680,000 00
8	58.50	60 feet per mile.	60,000 00	3,510,000 00
9	70.00	63 feet per mile.	30,000 00	2,100,000 00
Total---	396.00	Average cost per mile----------	49,163 00	19,468,750 00

* For the line via Point Concepcion, 13¾ miles longer, the maximum grade is 60 feet per mile; the average cost per mile $60,000. This makes the cost of the entire division $2,835,000, which exceeds the above $155,000 and increases the total cost to $19,623,750

The above estimates are exclusive of equipment. If we take a proportional amount for this distance of 400 miles of the entire amount estimated for the 32d parallel route, for first equipment, we shall have about $1,200,000 to add to the above, giving $20,823,750.

The examinations of the coast route having been completed, the Mojave river and basin were explored and found to have no connexion with the Colorado river and basin.

Proceeding to the Pimas villages, the initial point of the last reconnaissance, a division of the party was made; one half proceeding, via Tuscon, San Xavier, and the Cienega de los Pimas, to the river San Pedro, and the other up the Gila and San Pedro valleys. In his report of 1854, Lieutenant Parke suggested the probability of finding a feasible route from the Valle del Sauz to the Gila valley by passing between the Chiricahui mountains and Mount Graham, and continuing thence in a northwesterly direction, along the western base of Mount Graham to the Gila. His views in this respect were fully confirmed by the examinations of the division of the party retained under his own command. Following the Gila river to the mouth of the

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San Pedro, a favorable route was found for nearly the entire distance. The valley of the San Pedro proved to be wide and open, presenting no impediment to a rail or wagon road. There was an abundance of water, grass, and excellent soil, but no growth suitable for timber, though sufficient for fuel. Twelve miles from the mouth a large tributary was encountered, coming in from the east, and a party was organized for its examination. This party, descending the San Pedro for 35 miles from the Quercus cañon, crossed the mountains on the right bank to the plains west of Mount Graham, and, pursuing a northwesterly course for 36 miles, found the head of the "Aravaypa," as the newly discovered stream was called. The springs mentioned by Nugent, in his notes of Hay's trip, were found in the Playa de los Pimas, and a reconnaissance was made of Nugent's pass. The main detachment passed through the Puerto del Dado and the smaller through the wide pass,* between the Chiricahui mountains and Mount Graham; the two uniting on the Rio Sauz, about 15 miles below the Cienega. Examinations made eastward, across the Peloncillo (Sugar Loaf) mountains, resulted in the discovery of an excellent pass for a railroad in a more direct line than that of the route of 1854. From this range of mountains an easterly course was pursued, and connexion made with the former survey about 15 miles west of the point where Colonel Cooke's emigrant road diverges to the southwest.

The route between the Rio Grande and the Pimas villages may be divided into three parts—from the Rio Grande to the Valle del Sauz; from the Valle del Sauz to the mouth of the San Pedro; and from the mouth of the San Pedro to the Maricopa wells.

First division. *From the Rio Grande to the Valle del Sauz.*—From the Rio Grande the line ascends the mesa on the right bank by a grade of 60 feet per mile, and pursues a nearly direct westerly course, passing north of Sierra Florida, and 12 miles south of Cooke's spring, crossing the Mimbres bed 21 miles below the sink of the water, and passing through the lowest points of the great depression which characterizes the plateau of the Sierra Madre upon this route. The summit of the plateau is crossed near Cooke's emigrant road. The line then proceeds due west to the Sauz valley, through a pass in the Peloncillo range, (Sugar Loaf,) about 4 miles south of the Sugar Loak Peak. The maximum grade upon this division is 64.4 feet per mile. The mean elevation of the plateau is about 4,400 feet above the sea. The summits of the Florida pass, of the Sierra Madre, and of the Peloncillo pass, are, respectively, 4,600, 4,600, and 4,481 feet above the sea. The maximum grade (64.4 feet) is from the Peloncillo summit to the Sauz valley.

Second Division. *From El Sauz to the mouth of the San Pedro.*—From the Sauz the line is projected through the Railroad pass—the wide opening between the Chiricahui and Pinaleño (Mount Graham) ranges—thence, northwesterly, along the Pinaleño plain to the Aravaypa valley; down this valley to the San Pedro and to the Gila. The summit of the Railroad pass is 4,600 feet above the sea—582 feet lower than the Puerto del Dado—and is without doubt several hundred feet lower than any other pass through this range of mountains, south of the Gila. The Pinaleño plain has a mean elevation of about 4,400 feet. The descent of the Aravaypa to the cañon through the Calitro mountains is about 40 feet per mile, for 31 miles; the grade through the cañon and the San Pedro is 60.3 feet per mile, and thence to the Gila 14.4 feet per mile.

Third Division. *From the mouth of the San Pedro to the Maricopa wells.*—This division passes along the valley of the Gila, and presents a favorable location, except at about four points where salient spurs obstruct the stream. These are thin, and can be easily removed by

* Railroad pass.

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blasting. The maximum grade on this division is 15 feet per mile, and it may possibly be increased to 20 feet per mile, in a final location, for a short distance. The distance from the Rio Grande at Fort Fillmore to the Maricopa wells is 345.25 miles; being about 23 miles shorter than the line by the former survey. The highest elevation attained is 4,600 feet.

For the purpose of comparing this route with others, and to form an approximate estimate of its cost by an assimilation to roads already built, Lieutenant Parke has divided the country through which it passes into three characteristic portions, viz: prairie, rolling or hilly, and mountainous. The prairie section comprises that portion which will require but little more work than the adjustment of the sills for the reception of the rails; the hilly or rolling, that portion which will require light earth work and little or no rock cutting; and the mountainous, the bolder features of the line, where side locations and heavy earth and rock work will be necessary. The respective lengths of these divisions are:

Of prairie	230 miles.
Of rolling	65 "
Of mountainous	50 "
Total	345 miles.

The longest line of continuous prairie route is 130 miles, and the shortest 25 miles.

The longest line of rolling route is 30 miles, and the shortest 5 miles.

The longest line of mountainous route is 25 miles, and the shortest 5 miles.

The estimates for the final report are not yet completed. According to these estimates, so far as they have been made, the cost of the three sections will not exceed $30,000, $60,000, and $90,000 per mile, respectively, including equipment; making a total of $15,300,000, or an average cost per mile of the whole line of $44,000.

With reference to the supply of water between the Rio Grande and the Gila, Lieutenant Parke is of opinion that an abundance can be delivered on the line, at suitable distances, by conduits from the following localities: Cooke's spring, Rio Mimbres, Ojo de la Vaca, Agua Fria, Ojo de Inez, Cienega de Sauz, Croton springs, at the Playa de los Pimas, Antelope, Dove, and Castro springs, and Bear springs, at the head of the Aravaypa. The above localities are permanent watering-places, and have never been known to fail, notwithstanding the drains upon them by evaporation, by large herds of stock *en route* for the Pacific coast, and the frequent visits of the wandering Apaches. It is well known that while little rain is delivered upon the plains and valleys during the rainy season, the clouds are nearly always hovering over the mountains, dispensing copious showers, furnishing abundant supplies to the springs and streams enumerated. The longest distance between the points which can be supplied with certainty from permanent water is fifty-one miles. This occurs between Ojo de Inez and Cienega de Sauz; but there are two points in the Pyramid basin—one east and one west of the Pyramid range—where there is every reason to conclude that ample supplies of water can be procured by common or artesian wells. The distances between the water stations proposed along the line are as follows:

From Rio Grande to station 1, 31 miles.
From station 1 to station 2, 19 "
" " 2 " 3, 15 "
" " 3 " 4, 22 "

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From	station	4	to station	5, 17	miles.
"	"	5	"	6, 10	"
"	"	6	"	7, 20	"
"	"	7	"	8, 21	"
"	"	8	"	9, 28	"
"	"	9	"	10, 29	"

The supply of timber along this route is scanty. Cedar and pine are found in the Copper-mine mountains and near the sources of the Mimbres. The valleys of the Santa Cruz and the Gila contain dense groves of mezquite, which, particularly in the former locality, will furnish a large number of excellent cross-ties. Cotton-wood in limited quantities is found in nearly all the valleys where water-courses exist. There is not timber enough along the line, within fifty miles each way, to supply its demands.

The improvements in the former route made by this survey may be stated in brief to be: a more direct railroad line between the Pimas villages and the Rio Grande, with lighter grades, fewer summits, less elevation, greater supply of water, avoidance of a long jornada, and the introduction of cultivable valleys. It is probable, from the form and geological structure of the basins and plains, that ordinary wells may be made to furnish abundant supplies of water at distances not too great for the economical working of passenger trains. It has been indicated that in some localities artesian wells may be resorted to if needed.

As a post-route, Lieutenant Parke is of opinion that the route of the thirty-second parallel presents many advantages. By the construction of water stations at suitable distances, and by providing relays at various points, the mails could be transmitted from the Mississippi to San Diego in less than thirty days.

In addition to the results of his own examinations near the thirty-second parallel, Lieutenant Parke presents those of a detailed instrumental survey from the bay of San Diego, through Warner's pass, to the Colorado desert, made by Charles Poole, Esq., civil engineer, under the direction of the San Diego and Gila Railroad Company, organized under the authority of the legislature of California. Beginning at San Diego, this line ascends the San Diego river to San Isabel; passes through the valley of San Isabel and San José to Warner's pass and to the Indian villages of San Felipe, and from this point, through a cañon, to the desert. The maximum grade—107 feet per mile—is at the approach to the San Isabel summit. The grades to the summit of Warner's pass are 102 and 106 feet per mile. The distance from San Diego to Fort Yuma is 189.1 miles. The whole line is divided into two portions, the prairie and mountainous. Assuming in his estimate that the two are equal in length—stating, however, that "the cheaper is largely in excess"—Mr. Poole says: "we have ten miles at the western, and eighty-five at the eastern section, to be estimated at the lower rate."

The probable average cost of a single mile of the cheaper portion, to put the road in running order, including equipment, he estimates to be	$14,615 00
And for ninety-five miles	1,388,425 00
And for the more expensive portion, the cost per mile	65,085 00
Which for ninety-five miles is	6,183,075 00
Making a total of	7,571,500 00

These estimates of cost per mile are very much less than those for similar ground in the report of Lieutenant Parke, and in other War Department reports.

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Either standard applied to the two routes—the route to San Diego by Warner's pass, and that to San Pedro by the San Gorgonio pass—will give about the same total cost for each. If the object is to reach the bay of San Francisco, the route through the San Gorgonio pass is preferable, since, after reaching San Diego through Warner's pass, at a cost equal to that of the route through the San Gorgonio pass to San Pedro, there would remain the distance between San Diego and San Pedro—nearly 100 miles—over which it would be necessary to build the road.

In obedience to instructions from the War Department, dated May 1, 1855, a party was organized by Lieutenant R. S. Williamson, corps of Topographical Engineers, to examine the country lying between the Sacramento and Columbia rivers, with a view to ascertain the practicability of connecting their valleys by a railroad.

The first 200 miles of the route—from Benicia to Fort Reading, in the Sacramento valley—pass through a settled country. The average grade would not exceed five feet, and bridges would form the only expensive item in the construction of a railroad. Timber and water are abundant.

From Fort Reading, two routes to the Columbia river were examined—one east of the Cascade range, and the other between it and the Coast range. The former crosses the western branch of the Sierra Nevada by Noble's pass—a difficult location for a railroad, as there is an ascent, in a distance of 40 miles, of about 6,000 feet. A better line for crossing this range can be had by ascending Pit river along the route surveyed by Lieutenant Beckwith. A careful examination of the two cañons of this river developed results less favorable than those obtained by Lieutenant Beckwith, but nevertheless demonstrated the practicability of constructing a railroad near them.

The route beyond the upper cañon of this river lies for about 250 miles over a plateau—mostly sterile, though well supplied with water—elevated between 4,000 and 5,000 feet above the sea. This plateau extends from the western chain of the Sierra Nevada, northward, beyond the Columbia, gradually declining towards that river from the head of the Des Chutes valley.

Where timber is wanting in the immediate vicinity of the route, which rarely occurs, the mountains bordering it on the west will furnish an abundant supply.

For nearly the whole distance the average grade will be less than 25 feet, though in a few instances it rises to 100 feet, per mile. Difficult work will be found near Upper Klamath lake, and between it and Klamath marsh, where some heavy cutting and filling will be requisite. At the latter place it will be necessary to follow the cañon of Klamath river for about six miles. Near the head of the Des Chutes valley the party divided. Lieutenant Williamson, after a careful examination of the Cascade range in this vicinity, crossed it near Diamond Peak by a pass through which a wagon road has been made. Both the ascending and descending grades were found to be very abrupt. By the road, the ascending grades were for 2.5 miles 231 feet; for 4.7 miles 72 feet, and for 2 miles 42 feet per mile. The descending grades were for 5 miles 23 feet; for 3.7 miles 512 feet, and for 2.5 miles 311 feet per mile. Below this point they were all less than 125 feet per mile, and they continued to diminish rapidly. The above grades might be reduced by a side location to an ascending grade of 150 feet per mile for 7 miles, and a descending grade of 180 feet per mile for 16 miles, and perhaps even still further. There will be great difficulty in cutting through the dense forest. The summit of the pass is 5,600 feet above the sea.

After crossing the Cascade mountains, the Willamette valley was followed for 150 miles to

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the Columbia river, the route being favorable and the grades light. The total distance from Benicia to Fort Vancouver by this route is 760 miles.

Lieutenant Abbot, corps of Topographical Engineers, examined the Des Chutes valley to the Columbia river. The impracticability of constructing a railroad across or along the deep cañons cut in the plateau by that river and its western tributaries was fully demonstrated. Proceeding to Vancouver, the Cascade mountains were crossed a short distance south of Mount Hood, through a pass discovered by the party, which is practicable for a railroad, though probably inaccessible on the eastern side. Through this pass an ascending grade of 100 feet per mile would be required for 14 miles, and a descending grade of 123 feet per mile for 30 miles. The summit is 4,500 feet above the sea. For about 55 miles the construction would be difficult and expensive. The pass is a good one for a wagon road.

Lieutenant Williamson was compelled by the lateness of the season to return by water to San Francisco to prepare for a second survey in the Sierra Nevada, near the head of Carson river. Orders were left for Lieutenant Abbot to survey the route to Fort Reading lying between the Cascade and Coast ranges. After Lieutenant Williamson's departure, hostilities were commenced by the Indian tribes on this route, which rendered an escort for the small topographical party absolutely necessary. The exigencies of the public service in that region were such, however, as, in the opinion of the commanding officer at Fort Vancouver, to require him to attach the escort that had accompanied the party from California to his command, and it was therefore necessary either to abandon the duty or pass without an escort through a hostile Indian country. The latter course was adopted, and, although the absence of the escort rendered it impossible to make side explorations, the result of the survey proved the route to be more favorable than was anticipated. With the means to make side explorations, it is thought that a route might have been found through this fertile and settled country better adapted to a railroad than the line traversing the sterile region east of the Cascade range.

Through the Calapooya mountains, which separate the Willamette from the Umpqua valley, an excellent pass was found; giving, without difficult or expensive construction, an ascending grade of 31 feet per mile for 2 miles, and a descending grade of 66 feet per mile for 5 miles. The summit is 900 feet above the sea. In the Umpqua valley there are a few hills where the work would be difficult, but it is thought that these may be avoided and a good location obtained to the Umpqua cañon. This pass, a serious obstacle to the construction of a railroad, leads through the Umpqua mountains to Rogue river valley. Its summit is 2,000 feet above the sea. An ascending grade would be required of 207 feet per mile for 7 miles, with some heavy rock cutting, and a descending grade of 192 feet per mile for 2 miles. By side location the latter might be greatly reduced. It is possible that an examination of Cow creek cañon might have developed a more favorable route.

In Rogue river valley the Grave creek hills present the principal obstacle. By following Wolf creek to Rogue river they might probably be turned, but this examination could not be made. There is a pass from the valley to the great plateau east of the mountains, which, if as favorable as reported, would make a good connexion with the route surveyed by Lieutenant Williamson.

Through the Siskiyou mountains, which separate Rogue river and Shasta valleys, the construction of a railroad would be very difficult. The summit of the pass surveyed is 4,500 feet above the sea. An ascending grade of 130 feet per mile for ten miles, with a tunnel six miles

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long, and a descending grade of 106 feet per mile for 12 miles would be required. A better pass was reported, but again the want of an escort prevented the necessary examinations.

A recent survey made by a number of gentlemen from Shasta to determine the practicability of constructing a wagon road from Shasta valley to Fort Reading, by the valley of the Sacramento river, showed that project to be quite feasible. This route was not examined owing to the lateness of the season, there being no grass upon it at that time, and the animals being nearly broken down. The Trinity trail, which crosses Scott's mountains and Trinity mountains, was followed, and it proved utterly impracticable for a railroad.

By the return route the distance from Vancouver to Fort Reading is 470 miles.

Of the two routes surveyed from Benicia to the Columbia river, that east of the Cascade range may be considered practicable for a railroad. Three hundred and fifty miles of it lie through a fertile and settled region, where the construction would be easy. Two hundred miles are through an unsettled and barren country, but where no very heavy work would be required. The remainder of the route, which side locations would probably render 250 miles long, passes through a wilderness, and would require difficult and costly construction.

By the actually surveyed line west of the Cascade range, there are 500 miles where the construction would be easy, 100 miles that would be difficult and expensive, and 80 miles impracticable.

The field work terminated at Fort Reading, the season being too far advanced to admit of the intended exploration of the Sierra Nevada near the sources of Carson river.

Lieut. Williamson and party reached Washington in January, 1856, and have since been engaged in preparing the maps, drawings, and detailed reports of the survey. These are now in an advanced condition.

The party, under the direction of Captain John Pope, Topographical Engineers, organized by the instructions of the Department of January 5, 1855, to ascertain the practicability of constructing artesian wells upon the arid plains of Texas and New Mexico, has continued its labors during the past year. The region selected for the field of its first operations is described by Captain Pope as extending from the Rio Grande, east, to the headwaters of the Canadian, the Red river, the Brazos, and the Colorado, with their tributaries. It is included between the parallels of 30° and 36° N. latitude, and comprises an area of about 100,000 square miles. The river Pecos flows through it in a general S.S.E. direction, dividing it into two nearly equal parts. Three chains of mountains, generally parallel, averaging 3,000 feet above the plain and about fifty miles apart, lie to the west of the Pecos, the easterly range (called at the crossing of the 32d parallel the Guadalupe mountains) being fifty miles distant from that river. The strata of the valleys between these chains have been broken through by the upheaved mountains, and the ruptured edges lie along their sides at altitudes from 600 to 2,000 feet above the lowest lines of the basins between. From the notes accompanying the meteorological observations, it appears that the amount of precipitation for the year in rain and snow is from four to five times as great upon the mountains as it is upon the plains. Descending upon the summits, it is shed along the faces of the hard rock until it reaches the upturned edges of the broken and porous strata, through which it percolates. The water is thus intercepted from running over the country below, and forms reservoirs beneath the earth, which, if reached by boring at any point lower than the source, must rise and overflow the surface of the ground. The division of the region referred to lying east of the Pecos is a vast undulating prairie, called the Llano Estacado, or Staked Plain. It is a table land, about 3,500 feet above the level of the sea, with a dip

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towards the southeast. There is neither timber nor water upon its surface. It is subject to the same influences as the valleys above referred to, except that there is no mountain range at the east to correspond with the Guadalupe mountains, along the base of which the western edges of its strata outcrop.

The first point selected for boring was near the 32d parallel and about fifteen miles east of the Pecos. The party reached this position in the latter part of May, 1855, and the boring was commenced about the first of June. In three and a half months the well was sunk to a depth of 641 feet, through sandstone, marl, and clay. At a depth of 360 feet, pure and clear water was reached, which rose to within 290 feet of the surface of the ground. About 200 feet lower, water was again met with; and, at the lowest point attained, a third supply of water forced its way up through the sandstone in which the boring was being carried on. Here the rapid rising of the water so softened and undermined the beds of clay and marl that the well caved in, and it was found impossible to clear it. The details of these operations were given in my last annual report. It was mentioned in this report that the supply of tubing taken with the party, (500 feet,) which, from the character of the formation, had been deemed ample for all the trials to be made, had been found insufficient for this well, and that Captain Pope was obliged to suspend further boring upon the Staked Plain until he could receive additional tubing, and had in the meantime proceeded to the execution of the second duty assigned him—that of ascertaining the practicability of constructing artesian and other wells upon the route explored by Lieut. Parke between the Rio Grande and the Gila rivers.

The point selected for trial was ten miles distant from Fort Fillmore, on the plain west of the Rio Grande. The operations were begun here about the 1st November, and continued until the 15th February, at which time a depth of 293 feet had been bored through a porphyritic detrital deposit, slightly united by calcareous cement, with occasional beds of tenacious yellow and red clay. The boring, which was very difficult, had not passed through this formation when the party moved to the Pecos to meet the new supply of tubing, the arrival of which at that stream was expected to take place about the 1st of April. While the operation of boring was going on west of the Rio Grande, a reconnaissance was made to ascertain the practicability of boring artesian wells upon the Jornada del Muerto. The result, in the opinion of the geologist, made it probable that, to be successful, they must be carried to the depth of 1,500 feet, where the carboniferous strata would be found that outcrop on the mountains east and west of the jornada. From this opinion Captain Pope dissented, and gave reasons, connected with the thickness of the detrital deposits and the stratified rocks, composing in part these mountains, which induced him to think that it would not be necessary to carry the wells to more than half the depth assigned by the geologist.

The point west of the Rio Grande where the boring was made, lies in the continuation of the basin of the Jornada del Muerto; the thicknesses of the formations varying from those found in and near that jornada.

The party of Captain Pope arrived on the Pecos the second time about the last of March, 1856, and resumed the borings for an artesian well at a point five miles east of that where the work had been carried on the previous year. Commencing to bore on the 5th of April, the depth of 245 feet was reached by the 16th. Here water was encountered, which rose twenty-five feet in the well, and remained at the level to which the first water met with, on the preceding year, rose. The new supply of tubing was now needed, but it had not arrived. In my report to the Department of November 29, 1855, it was stated that, by your directions, measures had

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been taken to supply additional tubing to Captain Pope, in order that he might resume the work on the artesian well near the Pecos, in accordance with his instructions.

This tubing was prepared in Philadelphia, and, after being inspected by me, left there about the 20th January. It consisted of 1,200 feet of wrought iron tubes, three inches interior diameter, with a thickness a little exceeding $\frac{3}{16}$ of an inch, cut in lengths of nine feet, with screw joints. As a precaution, 400 feet of $1\frac{1}{4}$-inch wrought iron pipes, in lengths of nine feet, with screw joints, such as are used for boring rods, were sent with the tubing, as they would doubtless be of use for other purposes, if not wanted or not suitable for boring rods. The tubing and pipes reached New Orleans on the 5th February, and were shipped in the steamer for Indianola on the 7th of that month. Long delay occurred between Indianola and San Antonio, the roads being almost impassable, and the supply of tubes and pipes did not leave San Antonio until the 27th March, arriving at Captain Pope's camp on the Pecos on the 29th April. As before stated, on the 16th April the boring had been carried to the first water bearing stratum, 245 feet below the surface, beyond which it could not be sunk without the tubing. With the tubes a depth of 450 feet was soon attained, when the third piece of tube from the bottom gave way, spreading outside of and partly enveloping the piece below, and rendering it impracticable to continue the well further. As much of the tubing as could be got out was withdrawn, and the work again commenced at the surface on the 20th May. At the depth of 676 feet the lower stream, nearly approached the preceding year, was met with, the water rising to within 110 feet of the surface.

The supposition formed last year, upon piercing a stratum of dark blue shale, that the carboniferous strata of the Guadalupe mountains would be entered near this depth, proved to be unfounded. On the 20th July a depth of 809 feet was attained. The report upon the condition of the work at this date states that 1,200 feet of boring rods (wooden) had been taken originally with the party, but at that time they had been reduced by breakage, &c., to 860 feet. The hope was, however, expressed that, with the use of the ash tent poles of the party and command, (the country not affording supplies of suitable wood,) the depth of 1,000 feet would be attained by the close of August, if water was not sooner reached. This anticipation, however, was not realized. At the depth of 830 feet, the boring, after passing through strata of clays, marls, and soft sandstones, entered hard sandstone. On the 26th of August Captain Pope reported that the work had been brought to a close at the depth of 861 feet, as his boring rods had been exhausted and all the boring material in his possession consumed.

The tubing sunk during the boring was left in the well, which was so secured that the work may at any time be resumed. No new supply of water had been encountered below that met with at the depth of 676 feet.

It is to be regretted that the boring could not have been continued to the depth of about 1,000 feet, since there is great probability that a large supply of water, overflowing at the surface, would have been found at or near that depth, coming from the permeable carboniferous strata lying on the flank of the Guadalupe mountains. No information having reached this office of an anticipated deficiency of boring-rods or material other than tubing, no steps had been taken by me to supply them. Previous to the arrival of the tubing at the Pecos, some apprehension had been expressed that it would not admit of the use of the same drills that had been used for the first well; the diameter of the two sets of tubing proved, however, to be so nearly identical, that the drills for the first were adapted to the second without serious difficulty.

Geological and topographical surveys were made, in connexion with this work, on the lines

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